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CONSTANT CURRENT SUPPLY FOR THE DETERMINATION OF DETONATION VELOCITIES AND REFERENCE VOLTAGE SOURCE

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CONSTANT CURRENT SUPPLY FOR THE DETERMINATION OF DETONATION VELOCITIES AND REFERENCE VOLTAGE SOURCE

by

E. Nagy*

ABSTRACT

The following report is a description of the design, the calibration, and the operation of an instrument developed primarily as an accurate current source. The internal reference voltage, necessary for its operation, has been made accessible as an accurate voltage source for the calibration of laboratory recorders.

The instrument has been in use for approximately one year and has performed well.

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ALIMENTATION DE COURANT CONSTANT SERVANT À LA DÉTERMINATION DES VITESSES DE DÉTONATION ET DE SOURCE DE TENSION DE RÉFÉRENCE

par

E. Nagy*

RÉSUMÉ

Ce rapport présente une brève description de la conception, de l'étalonnage et du fonctionnement d'un appareil mis au point surtout pour servir de source de courant précis. La tension de référence interne nécessaire au fonctionnement de l'appareil sert de source de tension précise pour l'étalonnage des enregistreurs de laboratoire.

L'appareil est utilisé depuis un an environ et fournit un bon rendement.

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CONSTANT CURRENT SUPPLY FOR THE DETERMINATION OF DETONATION VELOCITIES AND REFERENCE VOLTAGE SOURCE

The following report is a description of the design, the calibration and the operation of the constant current and reference voltage source.

REQUIREMENTS

In the determination of detonation velocities a linear resistive element is placed next to the explosive material so that it is consumed at the same rate as the explosive during the detonation process. Then, by applying a constant current to the resistive element, the rate of change of the voltage will be directly proportional to the detonation velocity.

To prevent any heating near the explosive, the current through the resistor has to be low and controlled. The current source must be able to respond quickly to the very fast changes in load resistance and its regulation must be precise. The output of the current source must also be short-circuit protected.

The precision voltage source is required to calibrate laboratory instruments such as chart recorders and oscilloscopes.

Operation

Figure 1 shows the front panel of the instrument. The current and voltage are available at the banana plugs when the BNC selector switch is in the OFF position. Moving the switch either to the I or the V position will result in the current or the voltage source appearing at the BNC connector.

Outputs can be floating or ground referenced at the banana plugs, but referenced to ground only when using the BNC connector.

With the thumbwheel selector switch, voltages in 10 mV increments, from 0 to 9.99 V, and currents in 0.1 mA steps from 0 to 99.9 mA, can be selected.

Circuit Description

The circuit is composed of the power supply, the D/A converter and the amplifier.

The power supply (Fig. 2) consists of a step down transformer, a full-wave rectifier, a filter, and various regulators supplying the necessary voltages for circuit operation.

D/A conversion (Fig. 2) is done by a DAC-80, a 12 bit digital-to-analog converter. The BCD signals from the thumbwheel selector switches are converted into corresponding analog voltages, ranging from 0 to +10 volts, in 10 mV increments. The buffered output is then available at the V output terminals as a voltage reference source, as well as an internal reference for the amplifier circuit.

The amplifier circuit shown in Fig. 3 works as follows. Loading the current source will cause current flow through sensing resistor R_s and causes a voltage drop V_s across it. V_s is then amplified by difference amplifiers A_2 and A_3. A_4 and A_5 are buffer amplifiers with very high input impedances to prevent any loading on V_s. This output of the instrumentation amplifier is then fed into the inverting input of amplifier A_1. The purpose of this negative feedback loop is to keep V_s constant (and hence I_s constant). A_6 is a current amplifier, which, in conjunction with the 43 Ω output resistor and tuning capacitor C_s will be able to drive capacitive loads such as long coaxial cables. Outputs are short circuit protected to the common terminal.

Calibration

Begin by adjusting P_4 for zero offset on the internal reference voltage source. Then select 10 mA current with the thumbwheel switches and vary the load resistance between 0 Ω and 1000 Ω. Adjust P_1 until best current control is achieved (current reading remains a constant 10 mA). The offset zero current is adjusted with P_2 (all thumbwheel switches set to zero). Full scale setting is made with P_3.

Circuit Response

The response time of the constant current source was determined with the aid of the switching circuit shown in Fig. 4. Here with an external square wave signal the VMOS transistor is switched on and off, thereby switching the load resistance between 270 Ω and approximately 20 Ω and observing the output waveforms. Input currents of 15, 20, 30 and 45 mA were selected and measurements made with the aid of the NICOLET 4094 digital oscilloscope. A plot of the results can be seen in Fig. 5.

Accuracy

Current control accuracy, with 10 mA selected, was found to be 0.09% into a 1000 Ω load and 0.02% into a 300 Ω load. For the accuracy of the reference voltage output, refer to the electrical specification sheet of the DAC-80 in Appendix A.

SPECIFICATIONS

ELECTRICAL

Typical at 25°C and rated power supplies unless otherwise noted.

MODEL	DAC80-CBI			DAC80-CCD			
	MIN	TYP	MAX	MIN	TYP	MAX	UNITS
DIGITAL INPUT							
Resolution			12				Bits
						3	Digits
Logic Levels (TTL Compatible)[1]							
Logic "1" (at +40µA)[2]	+2		+5.5	+2		+5.5	VDC
Logic "0" (at -1.0mA)[3]	0		+0.8	0		+0.8	VDC
ACCURACY							
Linearity Error at 25°C		±1/4	±1/2		±1/8	±1/4	LSB
Differential Linearity Error		±1/2	+1, -3/4		±1/4	±1/2	LSB
Gain Error[4]		±0.1	±0.3		±0.1	±0.3	%
Offset Error[4]		±0.05	±0.15		±0.05	±0.15	% of FSR[5]
Monotonicity Temp. Range, min	0		+70	0		+70	°C
DRIFT[6] (0°C to +70°C)							
Total bipolar drift, max (includes gain, offset, and linearity drifts)[7]			±25			±25	ppm of FSR/°C
Total error over 0°C to +70°C[8]							
Unipolar		±0.08	±0.15		±0.08	±0.15	% of FSR
Bipolar		±0.06	±0.12		±0.06	±0.12	% of FSR
Gain		±15	±30		±15	±30	ppm/°C
Exclusive of internal reference			±10			±10	ppm/°C
Unipolar Offset		±1	±3		±1	±3	ppm of FSR/°C
Bipolar Offset		±7	±15		±7	±15	ppm of FSR/°C
Differential Linearity 0°C to +70°C		±1/2	+1, -7/8		±1/2	+1, -7/8	LSB
Linearity Error 0°C to +70°C			±1/2			±1/2	LSB
CONVERSION SPEED / V models							
Settling Time to ±0.01% of FSR For FSR Change							
with 10kΩ Feedback[9]		5			5		µsec
with 5kΩ Feedback		3			3		µsec
For 1 LSB Change		1.5			1.5		µsec
Slew Rate	10	20		10	20		V/µsec
CONVERSION SPEED / I models - of FSR							
Settling Time to ±0.01% For FSR Change							
10 to 100Ω Load		300			300		nsec
1kΩ Load		1			1		µsec
ANALOG OUTPUT / V models							
Ranges[10]	±2.5, ±5, ±10, 0 to +5, 0 to +10				0 to +10		Volts
Output Current	±5			±5			mA
Output Impedance (DC)		0.05			0.05		ohms
Short Circuit Duration	Indefinite to Common						
ANALOG OUTPUT / I models							
Ranges		±1, 0 to -2			0 to -2		mA
Output Impedance - Bipolar		4.4			4.4		kΩ
Output Impedance - Unipolar		15			15		kΩ
Compliance			±2.5			±2.5	Volts
INTERNAL REFERENCE VOLTAGE							
Maximum External Current[10]		+6.3	±200		+6.3	±200	Volts µA
Tempco of Drift, max		±10	±20		±10	±20	ppm/°C
POWER SUPPLY SENSITIVITY							
+15V Supply		±0.02			±0.02		% of FSR/% V_S
-15 and +5V Supplies		±0.002			±0.002		% of FSR/% V_S
POWER SUPPLY REQUIREMENTS							
DAC80	±14, +4.75	±15, +5	±16, +16	±14, +4.75	±15, +5	±16, +16	VDC
DAC80Z[9]	±11.4, +4.75	±12, +5	±16, +16	±11.4, +4.75	±12, +5	±16, +16	VDC
Supply Drain							
±15/±12V (including 5mA load)		±25	±35		±25	±35	mA
+5V (logic supply)		+20	±30		+20	±30	mA
TEMPERATURE RANGE							
Specification	0		+70	0		+70	°C
Operating (double above specs)	-25		+85	-25		+85	°C
Storage	-55		+100	-55		+100	°C

TABLE I. Electrical Specifications

NOTES:

1. Adding external CMOS hex buffers CD 4009A will provide CMOS input compatibility.
2. Logic "1" current = 40µA max at V_{IN} = +5.0V
3. Logic "0" current = -1.6mA max at V_{IN} = +0.4V.
4. Adjustable to zero with external trim potentiometer.
5. FSR means "Full Scale Range" and is 20V for ±10V range, 10V for ±5V range, etc.
6. To maintain drift spec internal feedback resistors must be used for current output models.
7. See discussion on page 6-161.
8. With gain and offset errors adjusted to zero at 25°C. See discussion on page 6-162.
9. DAC80Z supply range is ±12.0V min to ±16.0V max for 0 to +10V and ±10V.
10. Maximum with no degradation of specifications.

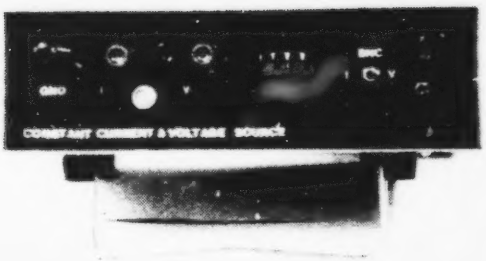


Fig. 1 - Photograph of front panel

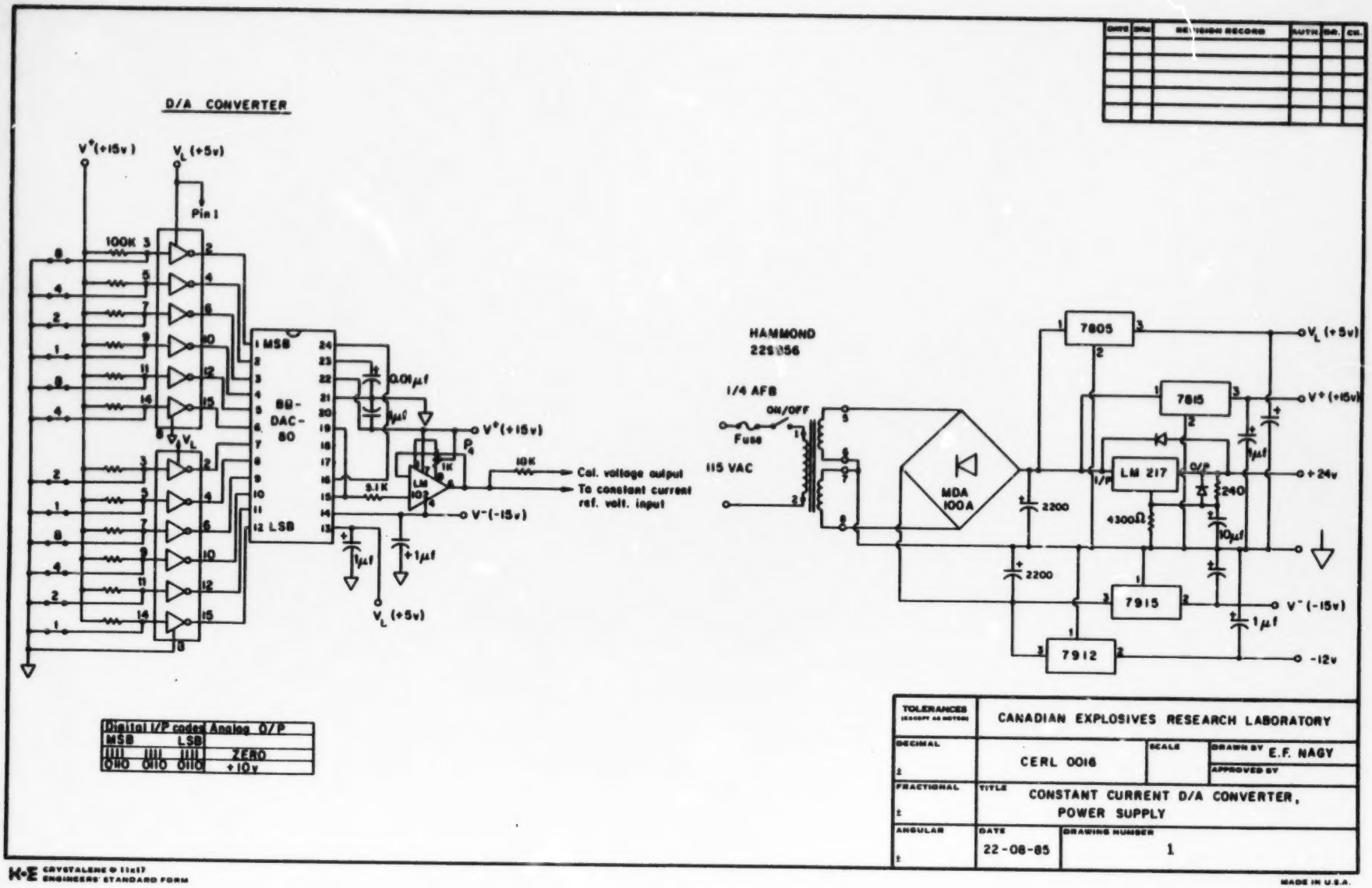


Fig. 2 - Power supply and digital-to-analog converter circuits

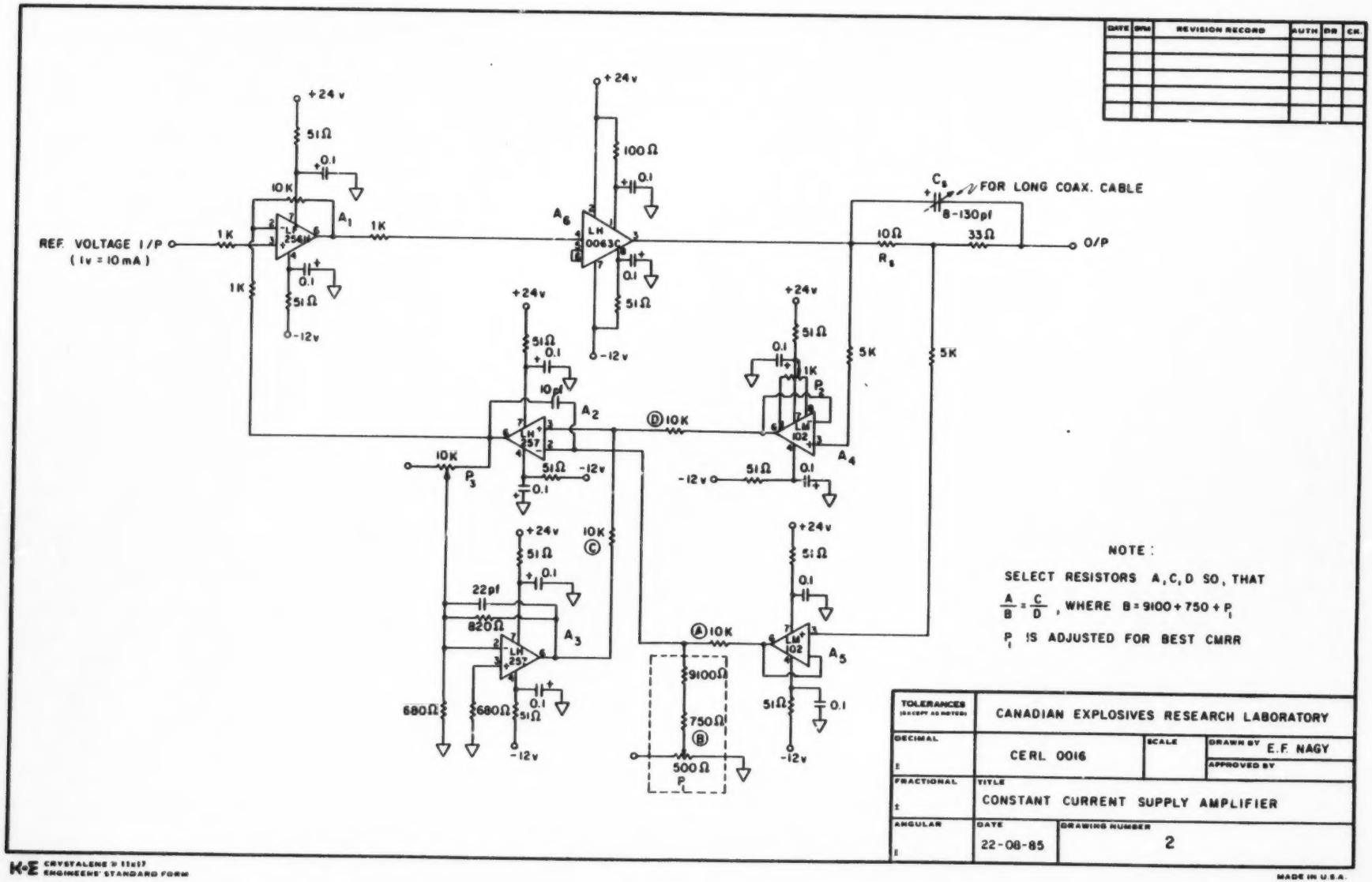
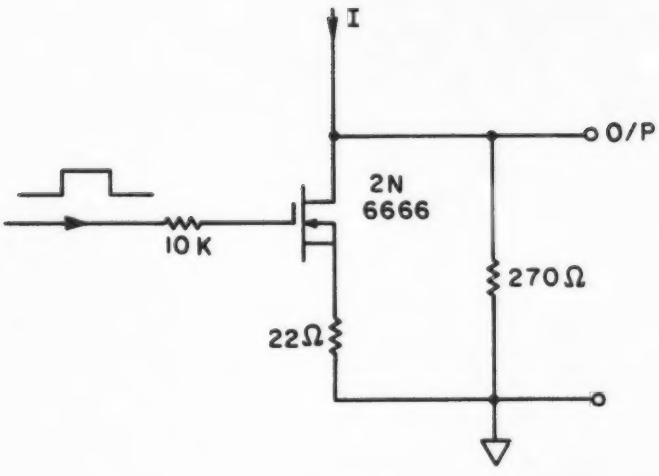


Fig. 3 - Amplifier circuit



TEST CIRCUIT

Fig. 4 - Evaluation test circuit

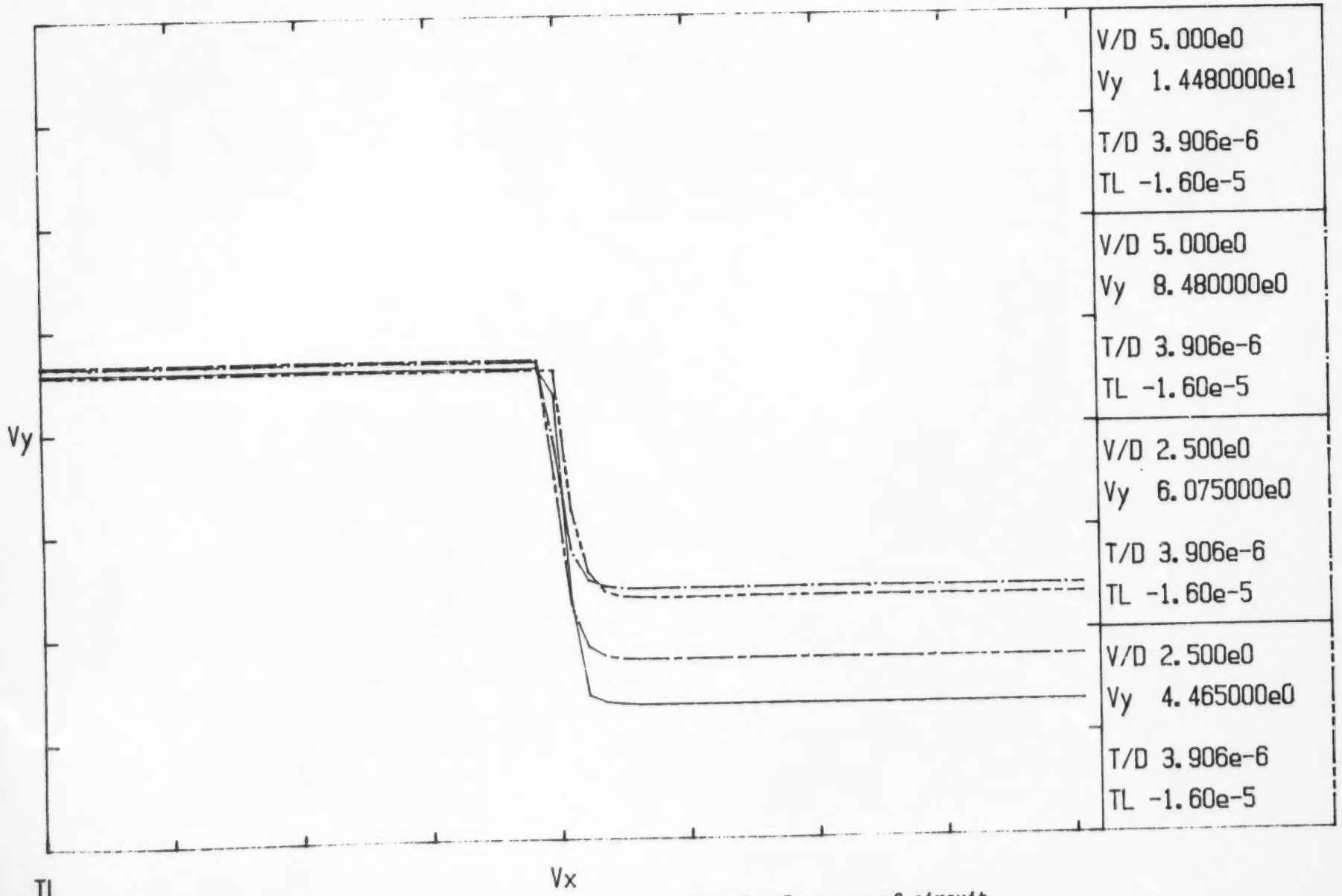


Fig. 5 - Response of circuit